WIRELESS COMMUNICATIONS DEVICE PSEUDO-FRACTAL ANTENNA

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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention generally relates to wireless communication antennas and, more particularly, to a pseudo-fractal antenna system and method using elements of fractal geometry.

2. Description of the Related Art

As noted in US Patent 6,140,975 (Cohen), antenna design has historically been dominated by Euclidean geometry. In such designs, the closed antenna area is directly proportional to the antenna perimeter. For example, if one doubles the length of an Euclidean square (or "quad") antenna, the enclosed area of the antenna quadruples. Classical antenna design has dealt with planes, circles, triangles, squares, ellipses, rectangles, hemispheres, paraboloids, and the like, (as well as lines). Similarly, resonators, typically capacitors coupled in series and/or parallel with inductors, traditionally are implemented with Euclidian inductors. The prior art

design philosophy has been to pick a Euclidean geometric construction, e.g., a quad, and to explore its radiation characteristics, especially with emphasis on frequency resonance and power patterns. The unfortunate result is that antenna design has far too long concentrated on the ease of antenna construction, rather than on the underlying electro-magnetics.

One non-Euclidian geometry is fractal geometry. Fractal geometry may be grouped into random fractals, which are also termed chaotic or Brownian fractals and include a random noise components, or deterministic fractals. In deterministic fractal geometry, a self-similar structure results from the repetition of a design or motif (or "generator"), on a series of different size scales.

Experimentation with non-Euclidean structures has been undertaken with respect to electromagnetic waves, including radio antennas. Prior art spiral antennas, cone antennas, and V-shaped antennas may be considered as a continuous, deterministic first order fractal, whose motif continuously expands as distance increases from a central point. A log-periodic antenna may be considered a type of continuous fractal in that it is fabricated from a radially expanding structure. However, log periodic antennas do not utilize the antenna perimeter for radiation, but instead rely upon an arc-like opening angle in the antenna geometry.

Unintentionally, first order fractals have been used to distort the shape of dipole and vertical antennas to increase gain, the shapes being defined as a Brownian-type of chaotic fractals. First order fractals have also been used to reduce horn-type antenna

geometry, in which a double-ridge horn configuration is used to decrease resonant frequency. The use of rectangular, box-like, and triangular shapes as impedance-matching loading elements to shorten antenna element dimensions is also known in the art.

Whether intentional or not, such prior art attempts to use a quasi-fractal or fractal motif in an antenna employ at best a first order iteration fractal. By first iteration it is meant that one Euclidian structure is loaded with another Euclidean structure in a repetitive fashion, using the same size for repetition.

Antenna designed with fractal generators and a number of iterations, which is referred to herein as fractal geometry, appear to offer performance advantages over the conventional Euclidian antenna designs. Alternately, even if performance is not improved, the fractal designs permit antennas to be designed in a new form factor. However, the form factor of a fractal antenna need not necessarily be smaller than a comparable Euclidian antenna, and it need not fit within the constraints of a portable wireless communication device package.

It would be advantageous if fractal geometry could be used in the design of antennas, to fit the antenna form factor within predetermined package constraints.

It would be advantageous if parts of an antenna's radiator could be shaped using fractal geometry, but other parts of the radiator shaped using non-fractal geometry to fit predetermined package constraints.

SUMMARY OF THE INVENTION

The present invention pseudo-fractal antenna incorporates elements of fractal geometry and Euclidian geometry. The patterns generated through the use of fractal geometry can generally be used to reduce the overall form factor of an antenna. However, due to the extreme space constraints in a wireless communication device, such as a telephone, even fractal geometry antennas are difficult to fit. Therefore, the present invention pseudo-fractal antenna forms a radiator using fractal sections, and non-fractal geometry sections for efficiently fitting the antenna within the assigned space.

Accordingly, a pseudo-fractal antenna is provided comprising a dielectric, and a radiator proximate to the dielectric having an effective electrical length formed in a pseudo-fractal geometry. That is, the radiator includes at least one section formed in a fractal geometry and at least one section formed in a non-fractal geometry.

The antenna can be either a monopole or a dipole antenna. For use in a wireless communication telephone, the antenna operating frequency can be approximately 1575 megahertz (MHz), to receive global positioning satellite (GPS) information, approximately 850 MHz to transceive cellular band telephone communications, or approximately 1920 MHz to transceive PCS band telephone communications.

Typically, the radiator has a fractal geometry section formed as a Koch curve. When the antenna is a dipole, the

counterpoise can also be a pseudo-fractal geometry with a section formed in Koch curve fractal geometry section. In some aspects, the radiator is a conductor embedded in the dielectric. Alternately, the dielectric is a dielectric layer, and the radiator is a conductive line overlying the dielectric layer.

Additional details of the above-described pseudo-fractal antenna, and a method for forming a pseudo-fractal antenna are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 2a is a schematic block diagram of the present invention wireless communications system.

Fig. 2b is plan view of the fractal antenna of Fig. 2a.

Fig. 2c is a schematic block diagram of the present invention wireless communications device system, using a pseudo-fractal antenna.

Fig. 1 is a plan view of the pseudo-fractal antenna of Fig. 2c.

Fig. 3 depicts a variation of the pseudo-fractal antenna of Fig. 1.

Fig. 4 is a monopole version of the pseudo-fractal antenna of Fig. 2c.

Fig. 5 is a drawing depicting in detail a transmission line interface suitable for use with a dipole antenna.

Fig. 6 is a flowchart illustrating the present invention method for forming a pseudo-fractal antenna.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 2a is a schematic block diagram of the present invention wireless communications system. The system 100 comprises a wireless telephone transceiver 102 having a communications port on line 104, connected to a fractal antenna 106.

Fig. 2b is plan view of the fractal antenna 106 of Fig. 2a. The fractal antenna 106 has a radiator 108, proximate to a dielectric 110, with an effective electrical length formed in a fractal geometry. As shown, the fractal geometry is a second order iteration of a Koch curve. However, the present invention is not limited to any particular order of iteration or curve. For example, the curve can also be Minkowski, Julia, Cantor, torn square, Mandelbrot, Caley tree, monkey's swing, or Sierpinski gasket. Although the antenna 106 has an overall length 112 that is less than a conventional straight line dipole, it may still not fit within the constraints of the system chassis. For example, the length 112 may still be too long, or the overall width 114 may exceed the constraints. The generation of additional iterations would not significantly reduce the overall length 112, but it would significantly increase the complexity of the shape, making the antenna 106 more difficult to manufacture.

Fig. 2c is a schematic block diagram of the present invention wireless communications device system 200, using a pseudo-fractal antenna. The system 200 comprises a wireless communication device receiver (or transceiver) 202 having a

communications port on line 204 connected to a pseudo-fractal antenna 206.

Fig. 1 is a plan view of the pseudo-fractal antenna 206 of Fig. 2c. The pseudo-fractal antenna 206 includes a dielectric 208 and a radiator 210 proximate to the dielectric 208 having an effective electrical length formed in a pseudo-fractal geometry. As defined herein, a pseudo-fractal geometry means that the radiator 210 includes at least one section 212 formed in a fractal geometry. Likewise, it means that the radiator 210 includes at least one section formed in a non-fractal geometry. As shown, sections 214-230 are formed in a non-fractal geometry.

As is well known in the art, a typical radiator 210 would have an effective electrical length of either a half-wavelength or a quarter-wavelength of the antenna operating frequency, depending upon the design and the antenna type. The antenna 206 can either be a dipole antenna as shown, or a monopole antenna, see Fig. 4.

When configured as a dipole, the antenna 206 further includes a counterpoise 232 having an effective electrical length. In one aspect of the invention, the counterpoise 232 has an effective electrical length formed in a pseudo-fractal geometry. That is, the counterpoise 232 includes at least one section 234 formed in a fractal geometry. The counterpoise likewise has an effective electrical length formed in a non-fractal geometry, sections 236-250.

As shown, the radiator fractal geometry section 212 and the counterpoise fractal geometry section 234 are formed in a Koch curve. More specifically, a second order iteration of the Koch curve is

shown. However, the present invention antenna is not limited to any particular generator (other generators or curves are listed above in the description of Fig. 2b), or number of iterations.

In some aspects, the radiator 210 (and counterpoise 232) is a conductor embedded in the dielectric 208. A large variety of conventional dielectric materials can be used for this purpose, even air. Alternately as shown, the dielectric 208 is a dielectric layer and the radiator 210 (and counterpoise 232) is a conductive line overlying the dielectric layer.

In one aspect of the antenna, the conductive lines are approximately 30 mil width half-ounce copper formed over an approximately 15 mil thick layer of FR4 material. Then, the approximate lengths of the non-fractal sections are as listed below:

reference designator 214 (236) – 0.094 inches
reference designator 216 (238) – 0.180 inches
reference designator 218 (240) – 0.045 inches
reference designator 220 (242) – 0.045 inches
reference designator 222 (244) – 0.180 inches
reference designator 224 (246) – 0.180 inches
reference designator 226 (248) – 0.232 inches
reference designator 228 (250) – 0.475 inches
reference designator 254 (256) – 0.140 inches

Each of the subsections a through h of fractal geometry sections 212 and 234 has an approximate length of 0.120 inches. The antenna operates at a frequency of approximately 1575 megahertz (MHz). The radiator 210 and counterpoise 232 each have an effective electrical length of a quarter-wavelength of the antenna operating frequency.

Fig. 3 depicts a variation of the pseudo-fractal antenna 206 of Fig. 1. As shown, the antenna 206 has a pseudo-fractal geometry radiator 210, as described above, and a "straight-line" conventional counterpoise section 300. Note that the counterpoise 300 has been truncated to fit on the page. The counterpoise 300 could also be formed with non-fractal bends for space conservation. As above, the radiator 210 and counterpoise 300 can be embedded in a dielectric or printed on a dielectric layer. In some aspects, the radiator 210 is printed on a dielectric and a whip counterpoise is embedded in the medium of air.

Fig. 4 is a monopole version of the pseudo-fractal antenna 206 of Fig. 2c. As above, the antenna 206 includes radiator 210 with at least one section 212 formed in a fractal geometry. Likewise, it means that the radiator 210 includes at least one section formed in a non-fractal geometry. As shown, sections 214-230 are formed in a non-fractal geometry. The antenna 206 also includes a counterpoise in the form of a groundplane 400. The dielectric 208 is interposed between the counterpoise 400 and the radiator 210.

The description of the radiator 210 is the same as the radiator of Fig. 1 and will not be repeated in the interest of brevity. As above, the radiator fractal geometry section 212 is shown formed in a Koch curve. Also as above, the radiator 210 can be a conductor embedded in the dielectric 208. Alternately, the dielectric 208 is a dielectric layer and the radiator 210 is a conductive line overlying the dielectric layer. The groundplane 400 can be a conductive area of chassis or circuit board proximate to the radiator 210.

The antenna 206 of Figs. 1 has a transmission line interface, and in some aspects of the system, the wireless communications device receiver 202 is a GPS receiver having a port connected to antenna transmission line interface on line 204. Therefore, the antenna 206 has operating frequency of approximately 1575 megahertz (MHz), to receive GPS signals. Alternately, the wireless communications device receiver 202 can be a telephone transceiver and the antenna 206 can operate at a frequency of approximately 850 or 1920 MHz. In some aspects, the receiver 202 can be a Bluetooth transceiver and the antenna 206 can operate at a frequency of approximately 2400 MHz.

As shown in Fig. 4 with a monopole antenna, in some aspects the transmission line interface is a simple connection to a coax cable 402, where the center conductor 404 is connected to the radiator 210 and the shield 406 is connected to ground 400. Alternately, the antenna can be connected to a microstrip or stripline transmission line (not shown). In some aspects as shown, at least one radiator non-fractal geometry section is formed further from the transmission line interface than the fractal geometry section 212. The concept of further as used in this context refers to the distance along the conductor. For example, section 250 is further from the feed than fractal geometry section 212 because it is further down the conductor than fractal section 212. Likewise in some aspects, at least one radiator non-fractal geometry section is formed closer to the transmission line interface than the fractal geometry section 212,

section 214 for example. Closer means that the non-fractal section is less far down the conductor from the transmission line interface.

Fig. 5 is a drawing depicting in detail a transmission line interface suitable for use with a dipole antenna. A balun antenna feed 500 has a transmission line interface 502, a lead port 504 connected to the radiator (section 214), and a lag port 506, 180 degrees out of phase at the antenna operating frequency with the lead port 504, connected to the counterpoise. Lumped element capacitors 508 and 510 are shown, along with inductors 512 and 514. However, the capacitive or inductive characteristics may also be enabled, either completely or partially, with microstrip or stripline elements.

Returning momentarily to Fig. 1, in some aspects as shown, at least one radiator (or counterpoise) non-fractal geometry section is formed further from the transmission line interface than the fractal geometry section 212 section 230 (252) for example. Likewise in some aspects, at least one radiator non-fractal geometry section is formed closer to the transmission line interface than the fractal geometry section 212, section 214 (236) for example.

Fig. 6 is a flowchart illustrating the present invention method for forming a pseudo-fractal antenna. Although this method is depicted as a sequence of numbered steps for clarity, no order should be inferred from the numbering unless explicitly stated. It should be understood that some of these steps may be skipped, performed in parallel, or performed without the requirement of maintaining a strict order of sequence. The methods start at Step 600. Step 602 forms a pseudo-fractal geometry conductive section.

Step 604, using the pseudo-fractal geometry conductive section, forms a radiator having an effective electrical length. Step 606 electro-magnetically communicates at an operating frequency responsive to the effective electrical length of the radiator.

In some aspects of the method, forming a pseudo-fractal geometry conductive section in Step 602 includes substeps. Step 602a forms a fractal geometry conductive section. In some aspects, the fractal geometry conductive section is a second order iteration Koch curve. Step 602b forms a non-fractal geometry conductive section. Then, forming a radiator having an effective electrical length in Step 604 includes creating an effective electrical length responsive to the combination of the fractal and non-fractal conductive sections.

Forming a radiator in Step 604 includes forming an antenna that is either a monopole or dipole antenna. In some aspects, Step 604 includes the radiator having an effective electrical length of either a quarter-wavelength (typically with a dipole) or a half-wavelength (typically with a monopole) of the antenna operating frequency. In one aspect of the method, Step 604 includes forming an effective electrical length with respect to an operating frequency of approximately 1575 megahertz (MHz).

In some aspects the method comprises further steps. When the antenna is a monopole antenna, Step 605a forms a counterpoise. Step 605b forms a dielectric interposed between the counterpoise and the radiator.

In other aspects, when the antenna is a dipole antenna, Step 605a forms a counterpoise using a fractal geometry conductive

section and non-fractal geometry conductive section. The counterpoise has an effective electrical length responsive to the combination of the fractal and non-fractal conductive sections. Then, Step 605b forms a dielectric interposed between the counterpoise and the radiator. In other aspects, Step 605c interfaces a transmission line to the antenna, and Step 605d creates a 180 degree phase shift at the operating frequency between the radiator and the counterpoise.

A pseudo-fractal antenna system and method have been described above. Specific examples have been given of monopole and dipole antenna types, but it should be understood that the present invention is not limited to a particular antenna design. Examples have also been given of a Koch curve fractal geometry section, however, the present invention is not limited to any particular fractal generator, or any particular order of iteration. Other variations and embodiments of the invention will occur to those skilled in the art.

WE CLAIM: